

Actigraphy Monitoring of Sleep Disturbance and Translations to Traumatic Brain Injury

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Introduction

- Sleep disturbance is often a primary predecessor and indicator of psychopathology such as Major Depressive Disorder (MDD)¹⁻³.
- Disturbed sleep is among the most frequent complaints following traumatic brain injury (TBI); increased disturbance is robustly associated with worsened outcomes, including depression, pain, and cognitive impairment⁴⁻⁶.
- The actigraphy use study examined the relationship between sleep disturbance, specifically sleep efficiency (SE), and depressive symptoms.
- As an index of sleep fragmentation, SE better captures sleep quality than does total sleep time, and indicates disruptions to the restorative properties of sleep.
- The TBI study hypothesized that increased reported sleep disturbance following TBI would positively predict subsequent post-injury depressive symptoms.
- Objective and efficient methods to measure sleep are needed to better assess and treat TBI and MDD symptoms, improving the tracking of treatment outcomes.

Actigraphy Study - Methods

Participants

- 75 adults, fluent English speakers. 53 females (mean age = 24.6, SD = 4.5).
- Community sample recruited on a continuum of depressive symptoms.

Initial Questionnaires

- During initial meeting, subjects completed mood and sleep related surveys including the Pittsburgh Sleep Quality Index (PSQI) and the Beck Depression Inventory (BDI-II) assessment.
- Subjects were also assessed for depressive symptoms using the Mini International Psychiatric Interview (MINI).



Subjects wore Actiwatches & completed daily questionnaires for one week of standard daily activities.

Actigraphy

- During the first session, subjects received wrist worn accelerometers (Philips Actiwatch 2) which were worn for 7 days continuously.
- Subjects reported factors related to their sleep patterns in daily questionnaires.
- Actigraphy data was processed and reported with Philips Actiware Software.

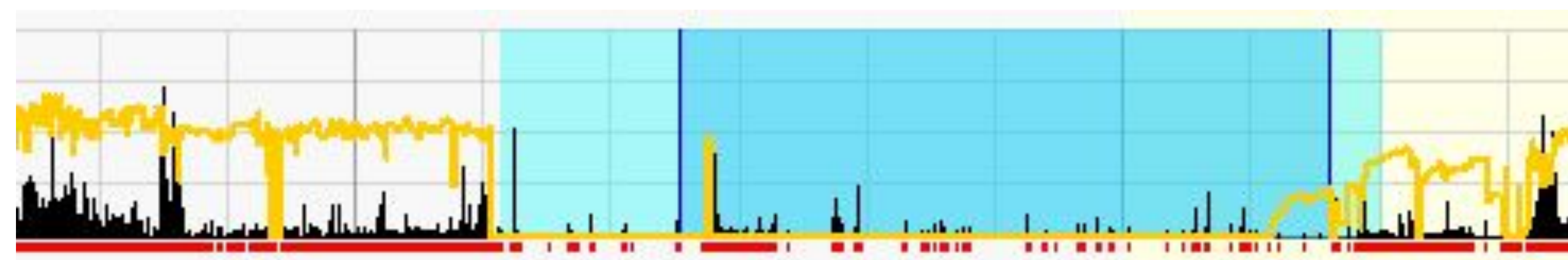


Figure 1. Sample actigraphy plot. Increased activity within the calculated sleep interval results in a lower calculated SE.

— Activity Level
— Sleep interval

Efficiency Scoring

- Daily SE calculated from sleep intervals. Equals: nocturnal sleep time / total rest interval time.
- Overall SE is mean of each daily SE.

Actigraphy Study - Results

- Negative relationship between PSQI and SE ($b = 0.907$, $p = 0.017$). 25 participants were excluded for missing PSQI data.
- Negative relationship between BDI-II and SE ($b = 0.903$, $p = 0.012$).
- Relationship between BDI-II and SE no longer significant after controlling for PSQI.

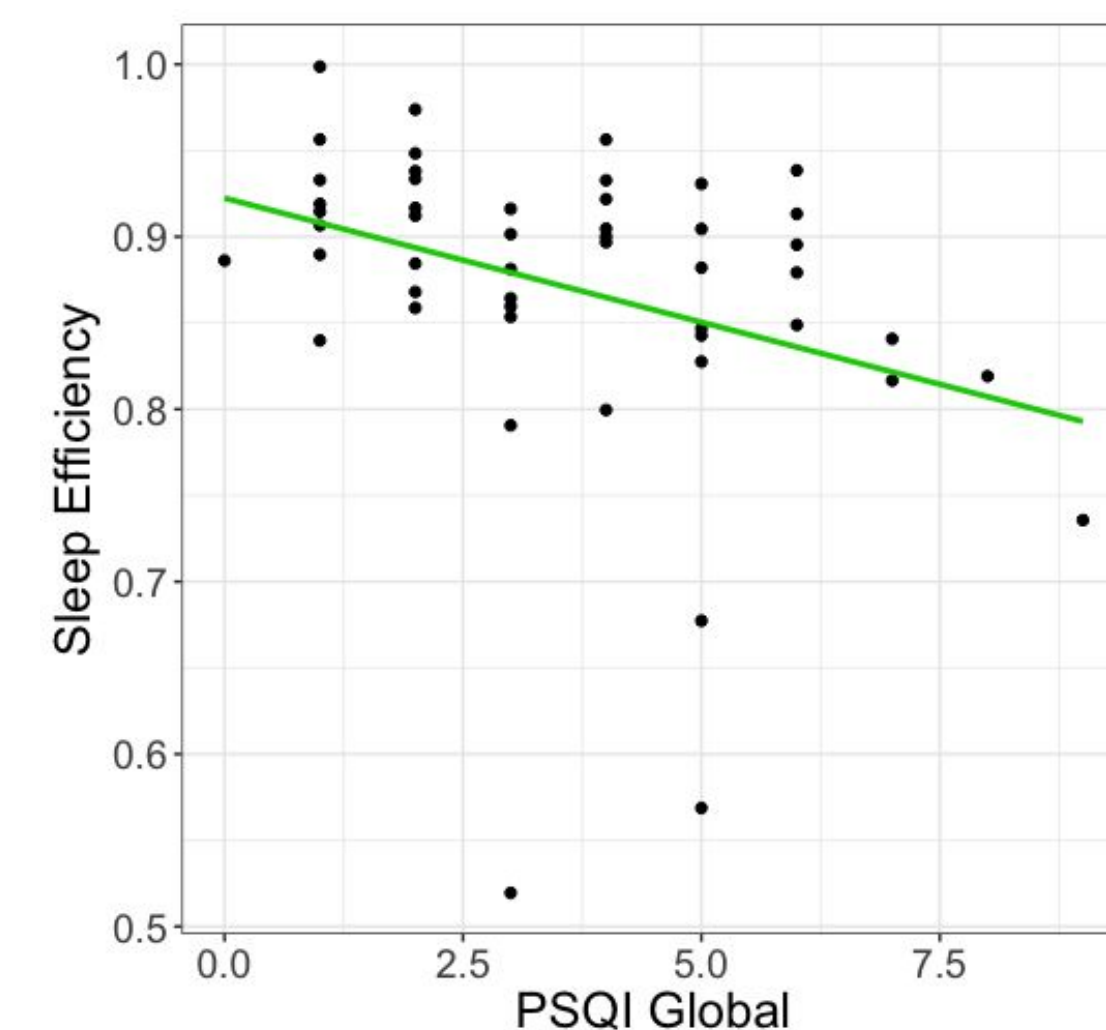


Figure 2. Sleep efficiency by PSQI Global.

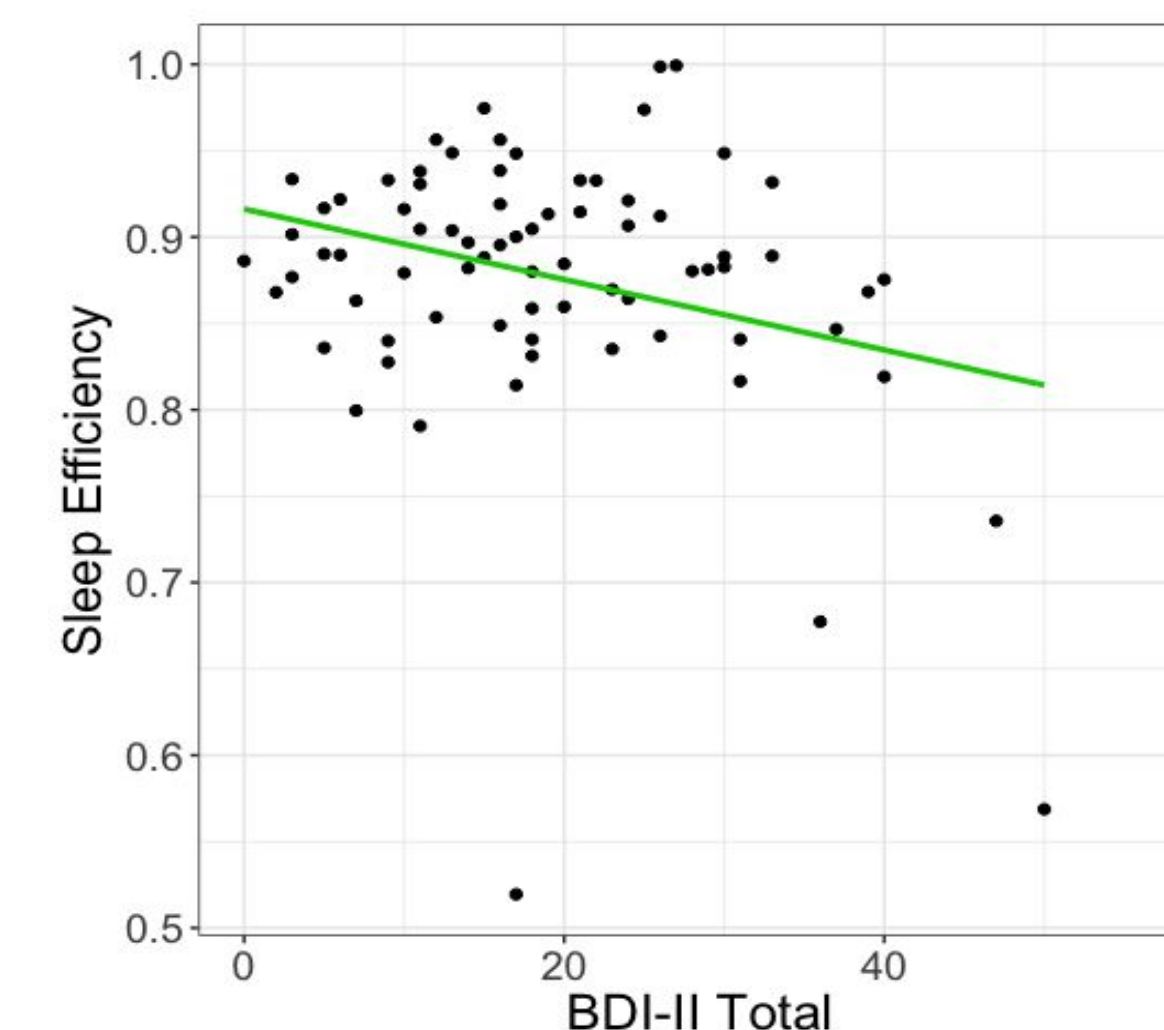


Figure 3. Sleep efficiency by BDI-II Total.

- In a linear mixed model with BDI-II and MDD Diagnosis as predictors, BDI was no longer a significant predictor of sleep efficiency ($b = 0.0004$, $p = 0.73$). MDD was trending ($b = 0.09$, $p = 0.07$).
- Significant interaction between BDI and MDD Diagnosis in predicting sleep efficiency ($b = -0.005$, $p = 0.02$). Stronger relationship between BDI-II and sleep efficiency in individuals with MDD.

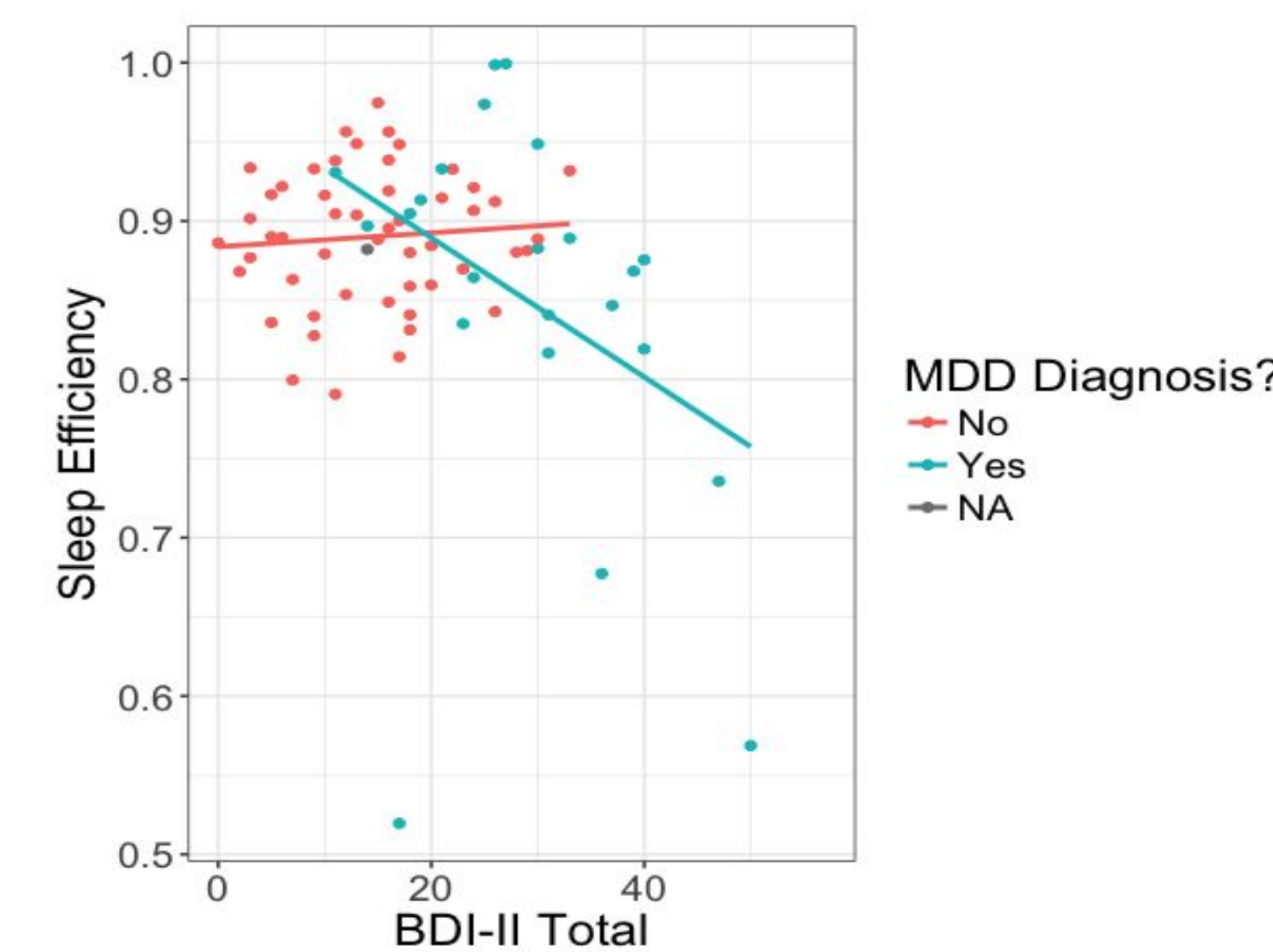


Figure 4. Sleep efficiency by BDI-II Total and MDD diagnosis.

TBI Study – Methods

Participants

- 305 adults from total sample of 599 in TRACK-TBI study⁷, fluent English speakers. 90 females, 215 males (mean age = 42.7 SD = 17.7).
- Inclusion criteria: Age 18+, acute brain CT, ability to provide consent.
- Exclusion criteria: pregnancy, incarceration, significant physical trauma, pre-existing conditions that interfere with assessment (MRI contraindication, neurological disease, etc.).

Measures - Injury Severity at Intake; Outcomes 3- and 6-months post-injury.

- Demographics (incl. medical history, e.g. prior TBI, history of depression).
- Glasgow Coma Scale (GCS): Level of consciousness, from 3 (most severe) to 15 (normal function). Scores ≥ 13 classified as mild TBI, < 13 as moderate/severe TBI.
- Sleep Disturbances: Two binary hypersomnia and insomnia questions, collapsed into composite, each ranging from 0 (no disturbance) to 2 (most disturbance).
- Sadness: Yes/No response. **3 Month Only.**
- Brief Symptom Inventory (BSI): Depression subscale (range 0-24). **6 Month Only.**

References

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TBI Study – Results

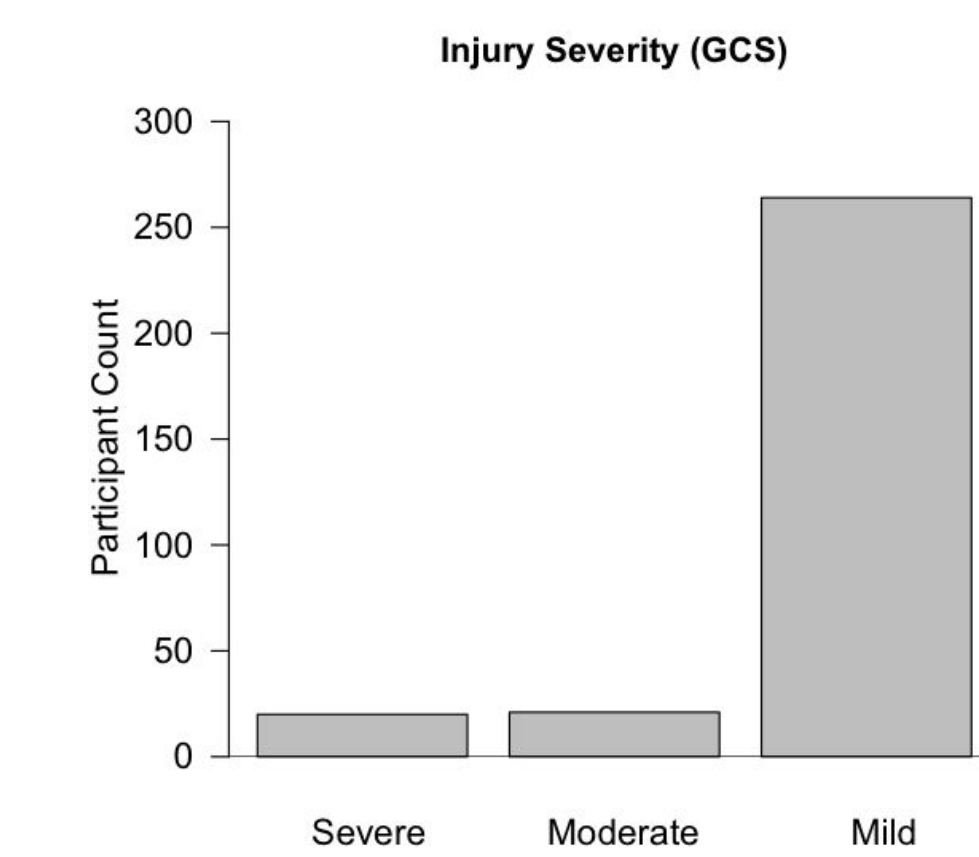


Figure 5. Distribution of GCS scores by category. Severe = 3-9, Moderate = 10-12, Mild = 13-15.

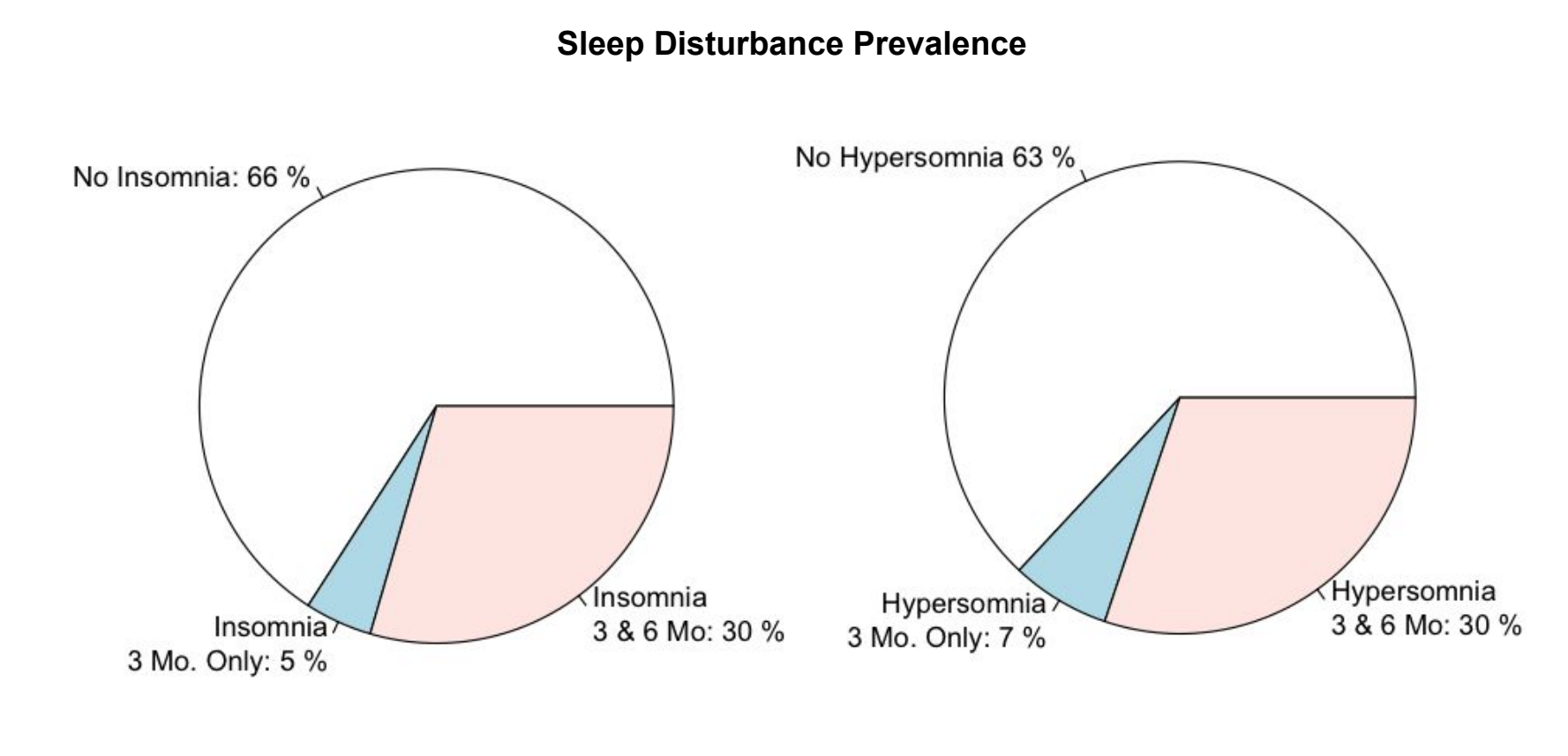


Figure 6. Proportion of the sample who reported symptoms of insomnia (left) and hypersomnia (right).

- Using Wilcoxon rank sum: significantly greater BSI scores relative to control for participants who reported insomnia ($p > .001$) and hypersomnia ($p > .001$).
- Models between sleep disturbance and BSI used **rate ratio** (RR) to measure associations between variables.
- RR significantly > 1 = significant effect of given variable (95% CI shown).

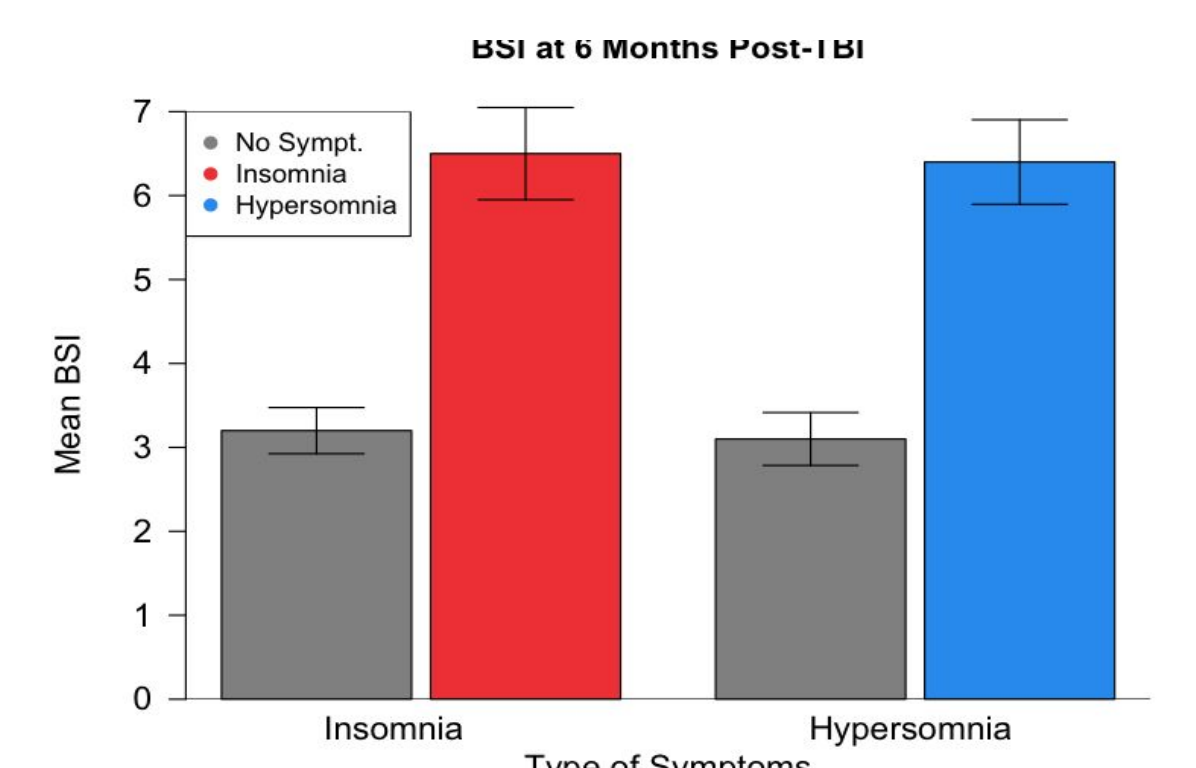


Figure 7. BSI 6-Months post-injury by 3-Month sleep disturbance.

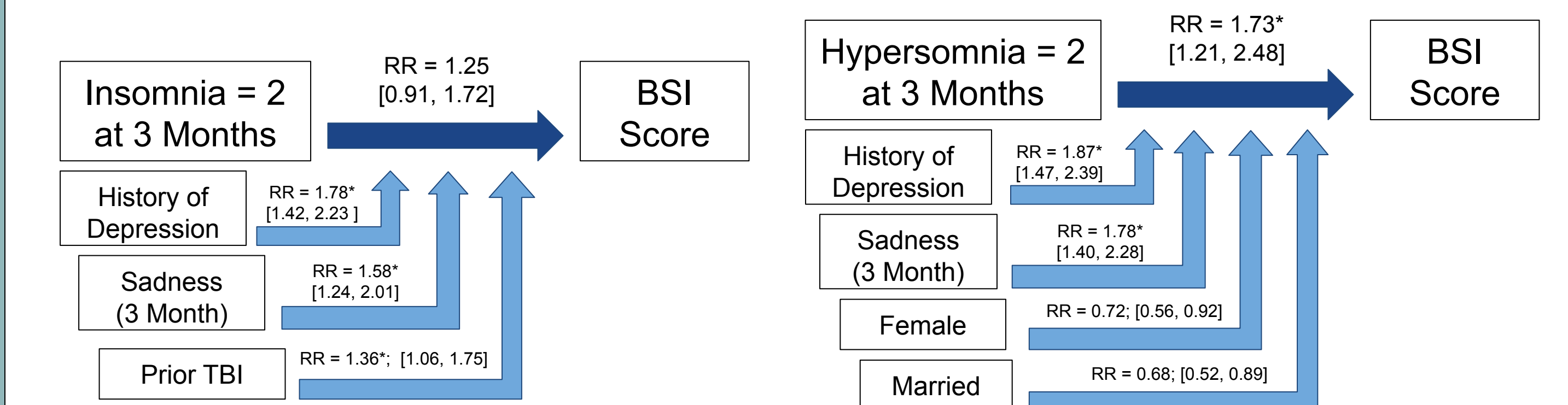


Figure 8. Illustration of regression model of insomnia at 3 months post-injury predicting BSI at 6-months post-injury.

Figure 9. Illustration of regression model of hypersomnia at 3 months post-injury predicting BSI at 6-months post-injury.

- Potential confounding variables controlled for if: a) non-significant in bivariate analysis with BSI, and b) effect estimate was not changed by $> 10\%$.
- Hypersomnia, but not insomnia, significantly predicts depression at 6-months post-injury.
- Models which also include participants who reported one insomnia/hypersomnia symptom also yield similar results, and significant variables.

Discussion

- Findings from the actigraphy study suggest that individuals with more depressive symptoms experience a decreased quality of sleep, specifically SE.
- The TBI study found that symptoms of hypersomnia but not insomnia were predictive of depression, after adjusting for confounding variables.
- Unlike actigraphic measures of SE, the two-item insomnia scale used in the TBI study did not assess difficulties in maintaining sleep and so cannot be considered a comprehensive assessment.
- While the TBI study failed to confirm previous findings regarding depression and difficulties maintaining sleep, actigraphy supports this link.
- These results demonstrate the utility of actigraphy for accurately measuring sleep quality objectively in a naturalistic setting, a critical feature which could benefit future research and treatment monitoring with MDD and TBI populations.
- Additionally, the ability of actigraphy to identify poor SE on a continuum of depressive symptoms indicates its potential for detecting early signs of changing symptoms in depressed and TBI populations.